CLEAN ENERGY TECHNOLOGY TRANSFER: A REVIEW OF PROGRAMS UNDER THE UNFCCC[1]

DAVID M. KLINE, LAURA VIMMERSTEDT and RON BENIOFF
National Renewable Energy Laboratory, Golden, Colorado USA

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Abstract. This paper describes the experience and results of programs designed to operationalize the technology transfer provisions of the United Nations Framework Convention on Climate Change (UNFCCC). These programs share a common goal of demonstrating modalities for developed country parties to fulfill their obligation under the UNFCCC to support technology transfer to developing country parties that facilitates their participation in global efforts to combat climate change. Several related U.S. bilateral programs and programs supported by the Climate Technology Initiative, a multilateral effort on behalf of a number of Organization for Economic Cooperation and Development (OECD) countries, are included in this review. The discussion highlights a number of common elements of the approaches of many of these programs as well as some differences. It presents case studies that focus on methods and results in China, Mexico, and Southern Africa, and catalogues and describes the implementation activities and results that these programs have achieved. It concludes by assessing the implications of this experience for the international community as it moves forward with the climate change technology transfer enterprise.

Keywords: CTI, Climate Technology Initiative, energy efficiency, renewable energy, sustainable development, TCAPP, Technology Cooperation Agreement Pilot Project, technology diffusion, technology transfer, UNFCCC

1. Introduction

This paper pursues two primary goals: (1) To describe technology transfer programs under the United Nations Framework Convention on Climate Change (UNFCCC) that will help inform developed and developing country representatives involved or interested in this work, (2) To inform the ongoing discussions under the UNFCCC on technology transfer methods and programs.

Two distinct elements contribute to the context for this review. The first is the evolving understanding of the economic, cultural, and social influences on technology transfer. The second is the better understanding of potential methods for enhancing technology transfer, based on the concrete experience from pilot efforts described in this paper. These pilot programs are part of bilateral and multilateral efforts to define mechanisms for fulfilling the technology transfer objectives of the UNFCCC.

The paper proceeds as follows: Section 2 describes technology transfer in general terms, outlines the evolution of the relevant literature, examines the rationale

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for technology transfer programs, and describes the context for technology transfer under the UNFCCC. Section 3 considers the history and characteristics of technology transfer programs under the UNFCCC and briefly reviews the issues and approaches that distinguish those programs from other technology transfer efforts. Section 4 describes the results of the UNFCCC technology transfer programs by examining several case studies, and surveys the actions and results achieved for the programs to date. This section concludes with a brief review of the issues that arise in measuring the performance of technology transfer effort, and a discussion of the metrics used in UNFCCC programs to date. Section 5 offers concluding remarks summing up the experience of climate change technology programs to date and suggesting next steps in moving this work forward.

2. The Process of Technology Transfer

The first part of this section defines and describes the general process of technology transfer, not specific to climate change technology transfer under UNFCCC programs. The second part explains the rationale for programs that promote technology transfer, both in general and in the specific case of the UNFCCC obligations. The third part of this section highlights the specific features of technology transfer programs designed to meet UNFCCC obligations. We use the term 'climate change technology transfer' to describe this last category of programs.

2.1. Technology Transfer Overview

There is surprisingly little consensus on what constitutes technology transfer. In fact, in much of the discussion of technology transfer, the term is not defined. The definition proposed by the Intergovernmental Panel on Climate Change (IPCC) will suit the purposes of this paper. In that lexicon, technology transfer comprises a 'broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, NGOs and research/education institutions' (IPCC, 2000).

The literature on technology transfer typically uses a similar definition, without restricting itself to climate change technologies. Theoretical literature on technology transfer perhaps begins with considerations of technology diffusion – the entry of a new technology into the market – e.g., as described by Mansfield (1961) and Blackman et al. (1973). Their framework is widely used in discussions of technology diffusion. Only relatively recently, however, have these approaches been applied to forecasting and policy analysis, where they become more relevant to technology transfer policies and actions. Decanio and Laitner (1997) suggest how Mansfield's diffusion model could be applied to forecasts of technology penetration, and to analysis of policies to accelerate penetration, using empirical methods.

Duke and Kammen (1999) apply such an approach to the evaluation of policies used to influence technology diffusion, also bringing to bear the theory of experience curves. Duke and Kammen examine the US Environmental Protection Agency's Green Lights Program, the World Bank's Photovoltaic Market Transformation Program, and the U.S. federal government subsidy on grain ethanol, and begin to uncover elements that can influence the success of such programs.

Much of the literature on technology transfer is concerned with moving 'high' technology within developed country settings, e.g. from government laboratories or military applications into civilian commercial use. In many cases, one of the major barriers is the transfer of protected or previously classified intellectual property. In this context, Kaplinsky (1990) lists five applicable delivery mechanisms:

- Transfer of equity in a company possessing the desired technology,
- License agreements with owners of the technology,
- Purchase of equipment containing the technology,
- Paying directly for the know-how involved, e.g. as blueprints,
- Hiring personnel in whom the technology is 'embodied,' i.e., who possess the requisite knowledge about the technology.

In both developed and developing country contexts, technology transfer efforts typically require what Kemp (1997) calls a 'change of technology regime.' Kemp defines a technology regime as a set of parameters that span a space of, or put bounds around, possible solutions to the design of specific products. The technology regime also includes the market and social context in which the product operates. One such regime culminated in the DC-3 airliner: a metal frame, low-wing aircraft using internal-combustion engines to drive propellers. The commercialization of jet engines in civil aeronautics, and the range of possible designs they supported, represented a regime change.

The commercialization of jet aircraft required more than technical success in building them. A large enough market had to be built around a reorganized route and fare structure to support a fleet of larger and more expensive planes than the previous generation of propeller-driven models. The order-of magnitude increase in aircraft speed made possible by jet engine required an array of changes in the supporting infrastructure, such as airport runways. In addition, faster airliner speeds enabled and encouraged wide-ranging changes in both business and leisure travel patterns, which in turn engendered other technological and social changes. Through this example, Kemp illustrates how regime change depends on the convergence of technical, economic, financial, organizational and sociological factors, greatly complicating the problem. He also points out that technology 'lock-in,' as described by Arthur (1988), often makes technology regimes resistant to change. He observes that '[o]ne reason why these technological transitions take so long (several decades) is the mismatch between new technologies and the socio-institutional context' (Kemp 1997).

This mismatch is even more likely in transfers of technology between different societies, either from North to South or from South to South. In fact, active resistance to the new technologies in the target communities has sometimes hindered technology transfer efforts.

Kemp also identifies factors that have contributed to the success of significant regime shifts, which should also be kept in mind in international technology transfer efforts. Unlike Kaplinsky's list of mechanism, Kemp considers the dynamics of the required market transition, and finds the following factors to be important:

- Available knowledge and expertise [in our case both in developed and developed country partners],
- The presence of early niche markets,
- Scope for branching and extension, of overcoming initial limitations, and for achieving cost reductions,
- The building of an actor network (suppliers, customers, regulators) whose semi-coordinated actions are necessary to bring about substantial shift in interconnected technologies and practices,
- The overcoming and accommodation of social opposition and consumer resistance.

(Kemp 1997)

Wilkins (2002) has drawn together a number of these considerations into a survey of technology transfer projects for renewable energy. Martinot et al. (2002) review a large number of renewable energy efforts. Reviews of some energy efficiency programs appear in Chandler et al. (1999) and Birner and Martinot (2002). All of these programs share a common goal of identifying and overcoming barriers to the market penetration of energy efficiency and renewable energy technologies. Different programs emphasize different instruments for this purpose, such as incentives, regulations, technology information, and energy price reform.

2.2. Rationale for technology transfer programs

A technology transfer program represents a concerted effort, often by both public and private sector actors to enhance the technology transfer process – as defined above – for selected technologies. In general, there are both efficiency and equity grounds for undertaking such programs.

Economic efficiency considerations include both environmental externalities and other factors that affect market efficiency. The technology transfer considered in this paper represents only one part of a larger effort to mitigate global climate change. Other, separate technology transfer programs target regional environmental concerns such as acid rain and ozone.

Other market failures that technology transfer programs address include the cost of technology information and the inefficiency of capital markets, particularly in developing countries. The cost of entering a new market can also produce a market failure if firms cannot appropriate the full value of those efforts when competitors enter the market. Lock-in of existing technologies also represents a market failure (Cowan and Kline 1996).

Equity considerations have been a major element of climate change technology arguments advanced by developing countries. Equity is brought into these discussions in a very broad way by the principle of 'common but differentiated responsibilities' expressed by the UNFCCC (United Nations, 1992[2]) and reaffirmed in the Delhi Declaration on Climate Change and Sustainable Development (United Nations, 2003). Subsequent UNFCCC decisions have begun to specify the technology transfer component of these differentiated responsibilities, as discussed below.

A number of technology transfer programs have been developed to address these economic efficiency and equity issues. This paper considers programs that address technologies applicable to climate change mitigation and to adaptation to climate change[3]. It also examines technology programs under the UNFCCC framework that have not been reported to date in the open literature. These programs have focused primarily on clean energy technologies such as renewable energy and energy efficiency technologies.

2.3. Features of Climate Change Technology Transfer

Climate change technology transfer generally includes the following features, not necessarily shared with technology transfer programs in other areas:

- A focus on technologies that are applicable to the global response to potential climate change,
- Explicit prioritization process in which relevant stakeholders select the climate change technologies of greatest economic and social benefit to the recipient country,
- A focus on building the capacity of developing country partners to adapt, promote, and use the designated technologies,
- 'Market conditioning' activities such as public awareness and education efforts (e.g., Birner and Martinot 2002).

IPCC (2000), although somewhat dated in this fast-moving area, provides a useful description of the methods and issues of climate change technology transfer from a very broad perspective.

3. UNFCCC Technology Transfer Methods and Programs

3.1. Overview

Article 4.5 of the UNFCCC establishes the goal of climate change technology transfer by specifying that '[t]he developed country Parties ... shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention' (United Nations 1992). This passage is generally interpreted as requiring the developed country parties to identify resources and establish programs that facilitate effective technology transfer. The programs reviewed below represent an effort to define, by concrete example, how this obligation can be fulfilled in practice.

The UNFCCC has entertained active negotiations on technology transfer since its inception. The Parties made significant progress in achieving agreement on broad principles at its 7$^{\text{th}}$ Conference of the Parties in Marrakech, Morocco. The resulting decision (UNFCCC 2001) established a framework for implementation of technology transfer under the UNFCCC that includes five major elements:

- Technology transfer needs assessments
- Technology information
- Enabling environments
- Capacity building
- Financial, institutional and methodological mechanisms for technology transfer

The Experts Group on Technology Transfer was chartered as part of this decision to advise the UNFCCC on further refinements to the definition of the technology transfer process. Among the most important decisions yet to be made is how the process is to be financed.

This paper reviews programs that have been developed as pilot efforts to demonstrate and refine approaches for implementing the technology transfer requirements of Article 4.5 of the UNFCCC, cited above. One set of programs, the Technology Cooperation Agreement Pilot Project (TCAPP) and a related program, the Climate Technology Partnership (CTP), are bilateral efforts between the U.S. and a number of developing countries. Another program, the Cooperative Technology Implementation Plan (CTIP) program, represents a similar approach within the multilateral framework of the Climate Technology Initiative (CTI). CTI was established in 1995 by a coalition of OECD countries and the European Union[4] (EU). We will refer to TCAPP/CTP and CTIP collectively as climate change technology transfer or CCTT programs. This paper also describes key elements of a methodology that is under development by the United Nations Development Program (UNDP) and the Global Environment Facility (GEF) for climate technology needs assessments and describes related technical support provided by CTI for such needs assessments.

3.2. Climate Change Technology Transfer Programs and Methods

3.2.1. *TCAPP and CTP*

The U.S. government launched the TCAPP in 1997 to provide a model of a country-driven and market-oriented approach to technology transfer implementation. TCAPP aimed to demonstrate how developed countries could fulfill their obligation under UNFCCC Article 4.5 to actively assist the developing country parties through technology transfer. These efforts began by establishing which technologies and modalities each developing country partner sees as most beneficial and continued by working with these countries to implement actions to attract investment in these technologies. TCAPP emphasized a market-oriented approach as the only feasible mechanism for technology transfer that will continue and grow on its own, rather than relying on continued direct support from donor agencies.

TCAPP assisted the governments of Brazil, China, Egypt, Kazakhstan, Mexico, Philippines, and South Korea in identifying their highest priority clean technologies for meeting their sustainable development goals while reducing greenhouse gas (GHG) emissions[5]. Following the identification of these priority technologies, TCAPP worked with the countries to develop and implement an initial portfolio of public and private sector actions to promote and facilitate private investment in these priority clean energy technologies. International businesses and donors are actively engaged in the implementation of these clean energy technology actions. TCAPP demonstrated an effective methodology for identifying priority technologies and for design and initial implementation of actions to promote investment in these technologies. The program concluded in 2001, when the U.S. launched a new effort to provide more focused support for implementation of selected high priority clean energy technologies in many of the countries that participated in TCAPP. This effort is referred to as the Climate Technology Partnership (CTP).

TCAPP was the first program to define climate change technology transfer through the development of concrete, on-the-ground projects in developing countries. TCAPP developed and documented a preliminary methodology for this work, which was refined over time using the program experience.

The work began under the guidance of the following principles, laid out in NREL (1999):

1. **Technology transfer must be host-country driven.** Climate change technology transfer priorities should be selected based on the potential benefits to the country as defined by in-country stakeholders, as well as the potential GHG-emission reductions.
2. **Large-scale technology transfer can best be achieved by facilitating private sector action to develop sustainable markets for clean energy technology.** Commercial markets are the primary vehicles for technology transfer; the most important role for government is to enable private-sector activity.
3. **Successful technology transfer requires collaboration at many different levels:**
   - Among host country government agencies, businesses, nongovernmental organizations (NGOs), and technical experts
   - Between developing country and industrialized country technical experts
   - Between developing countries and international businesses and investors, and
   - Between developing countries and international donors.

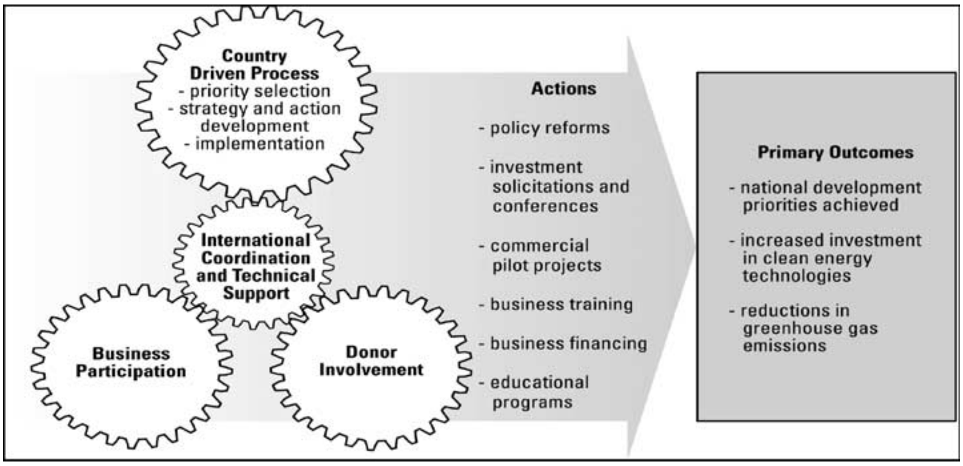

Figure 1. Overview of technology cooperation agreement pilot project methodology.

The overall organization of the partners in the effort, their actions and their intended results is illustrated in Figure 1. This methodology builds on relationships and some of the process elements of the previous work of the U.S. Country Studies and related efforts that supported the development of National Communications to the UNFCCC (USCSP 1998, 1999). As the TCAPP work progressed, an understanding of the process emerged that can be represented in the following sequence of steps. The activities involved in each of these phases are described in more detail (NREL 1999).

1. Form host country teams representing the necessary group of stakeholders.

   Both the right collection of stakeholders and their commitment to the process are obviously essential to the success of the enterprise. Some countries have also formed teams within the stakeholders group to consider specific topics.
2. Agree on a process for establishing technology priorities, including both criteria and decision rules.

   The decision process influences both how the views of all stakeholders are incorporated and the involvement and ownership that the stakeholders have in the project. The process will consider the criteria to be used, the decision rule, and identify the information that will be needed to carry it out. The TCAPP country teams have been notably successful in developing processes that worked well in their particular situations.
3. Assemble information on technologies, priorities, and barriers to technology implementation.

   As mentioned above, this information is needed for the prioritization process. Much of it may be available in existing studies such as national greenhouse gas mitigation and adaptation assessments.
4. Select three to six priority technology areas using the agreed-upon process.

Experience with this part of the process suggests that it is not practical to consider more than six technology areas at one time, and in most cases, the list of active areas has been shorter than that. TCAPP teams have also found it useful to select these priority areas from a much longer list, representing all the technology areas considered important by stakeholders.

5. Prepare a technology cooperation framework and communicate results to the larger group of stakeholders not directly involved in the process.

   This framework is a document that communicates the priorities and prioritization approach to key country decision makers and other stakeholders inside and outside of the country. This framework helps focus the future work of the country team and will be helpful in attracting support for implementation from government agencies, businesses, and international donors.
6. Develop a market development strategy for each priority area including actions to address key barriers.

   For each of the technology areas, the market implementation strategy begins by identifying the key barriers, and establishes a framework for actions to address them. Private sector input is particularly critical in developing these strategies.
7. Design specific actions to address legal and institutional barriers.

   In many cases, successful technology transfer will require the design and implementation of actions to address legal or institutional barriers before a sustainable market for the technologies can be created. These actions vary considerably depending on the legal and institutional context in each country.
8. Design actions to facilitate direct investment in the priority technology areas.

   Together with the legal and institutional policy actions, these direct investment facilitation actions are the prime movers of technology transfer. Section 4.2 describes the range of direct actions that have been undertaken in TCAPP and related efforts.
9. Implement the actions described in 7 and 8.

   Implementation can only succeed as a collaborative effort involving host country organizations, private sector companies and investment organizations, international donors, and technical experts.
10. Evaluate lessons learned, and incorporate them into ongoing technology transfer activities.

    This evaluation allows an ongoing assessment and refinement of the actions to ensure that they are meeting development needs and climate change goals and are responding to changing circumstances. This assessment can also inform the related efforts of other countries, and can be incorporated into the ongoing discussions and negotiations on technology transfer at the UNFCCC.

3.2.2. *The climate technology initiative (CTI)*

CTI is a multilateral initiative of 16 member countries from the OECD and the EU designed to facilitate the international diffusion of climate friendly technologies.

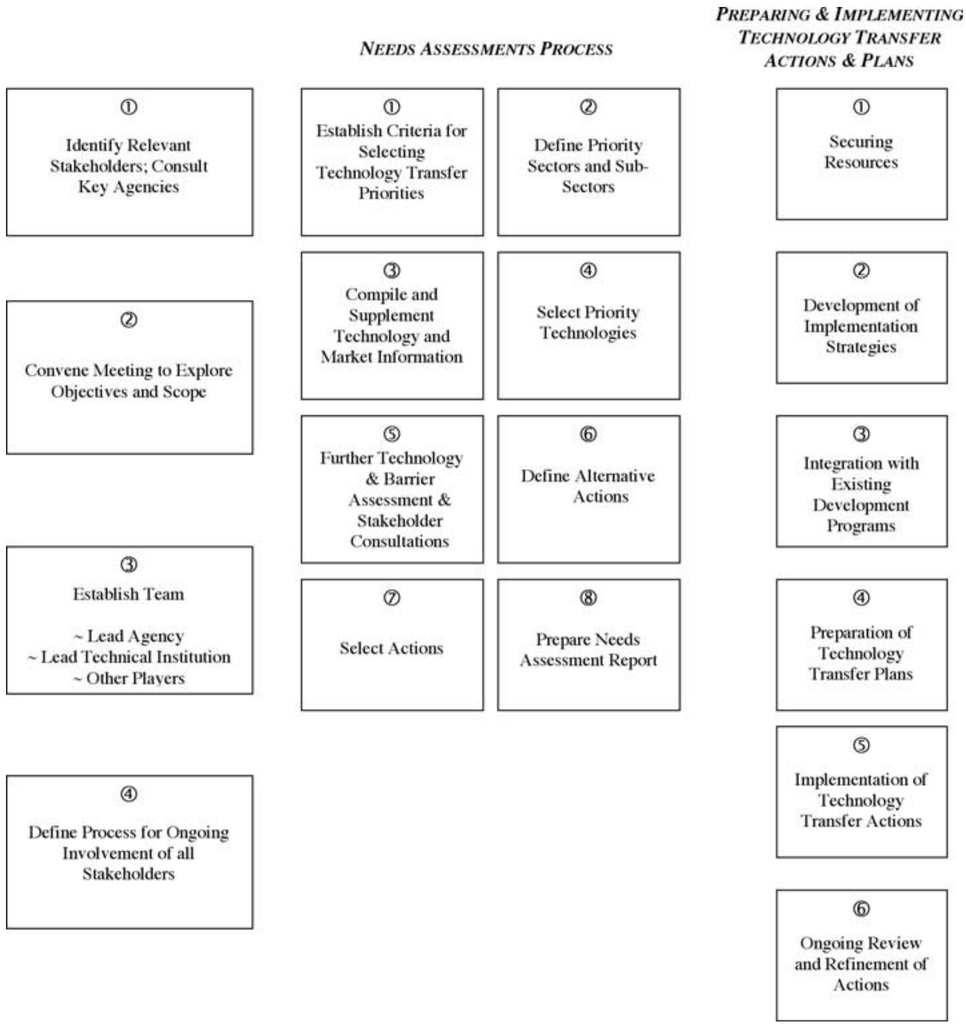

Figure 2. A simplified view of the cooperative technology implementation plan methodology.

Cooperative Technology Implementation Plans (CTIPs) are part of the work of the CTI.

A CTIP starts with establishment of priorities and preparation of an action plan and then implementation of selected actions in this plan. CTI member countries pool their resources in providing technical and financial support for the work of developing countries participating in the CTIP program. The CTIP effort is currently active in Southern Africa (a regional initiative with the 14 countries in the Southern African Development Community), India, and Nigeria.

CTI has built on and refined the TCAPP approach in its multilateral context, which includes the active participation of numerous OECD countries. Both the experience gained in the TCAPP and CTP programs and the multilateral nature of

CTI has led to changes and enhancements to the methodology. Figure 2, taken from CTI (2002), provides an overview of the CTIP methodology.

CTI also sponsors other closely related activities, including providing technical assistance to countries undertaking Technology Needs Assessments with funding from the United Nation GEF. The GEF through UNDP and Environment Program (UNEP) has provided financial support to over 50 countries for technology needs assessments. Through these needs assessments, countries identify their priority technologies and actions for accelerating implementation and diffusion of these technologies. CTI currently provides technical assistance for technology needs assessments funded by the GEF to Ghana, Bolivia and Malawi, and is exploring opportunities to provide support to several other developing country partners.

3.2.3. *UN/Global environmental facility programs*

Through the GEF, UNDP and UNEP have provided support to developing countries and countries in transition in preparing their National Communications to the UNFCCC. UNDP and UNEP have recently provided many countries with 'top-up' funding for these national communications, which includes support for conducting Technology Needs Assessments. UNDP has prepared a methodology to help guide countries in conducting such technology needs assessments, drawing on the experiences of TCAPP, CTP and CTIP, the IPCC report on technology transfer, and other sources. Figure 3, from UNDP (2002), illustrates the broad features of the UNDP methodology.

4. Results of CCTT Programs

This section summarizes results of the CCTT programs. We begin with case studies of CCTT in China, Mexico, and Southern Africa. Section 4.2 presents a comprehensive list of technology implementation actions undertaken in all of the participating countries.

4.1. Case Studies from Market-Based Technology Transfer

These case studies of CCTT describe country participation, priority technology selection, and identification and mitigation of technology barriers for each country. In the section on technology barriers, we focus on a single technology in each country: grid-connected wind electric power in China; Energy Service Companies in Mexico; and cogeneration in Southern Africa.

4.1.1. *Country stakeholders*

Country stakeholders participating in the selection should generally include the following organizations.

- Government agencies, e.g. environment, energy, infrastructure, transportation agriculture, forest, and water;

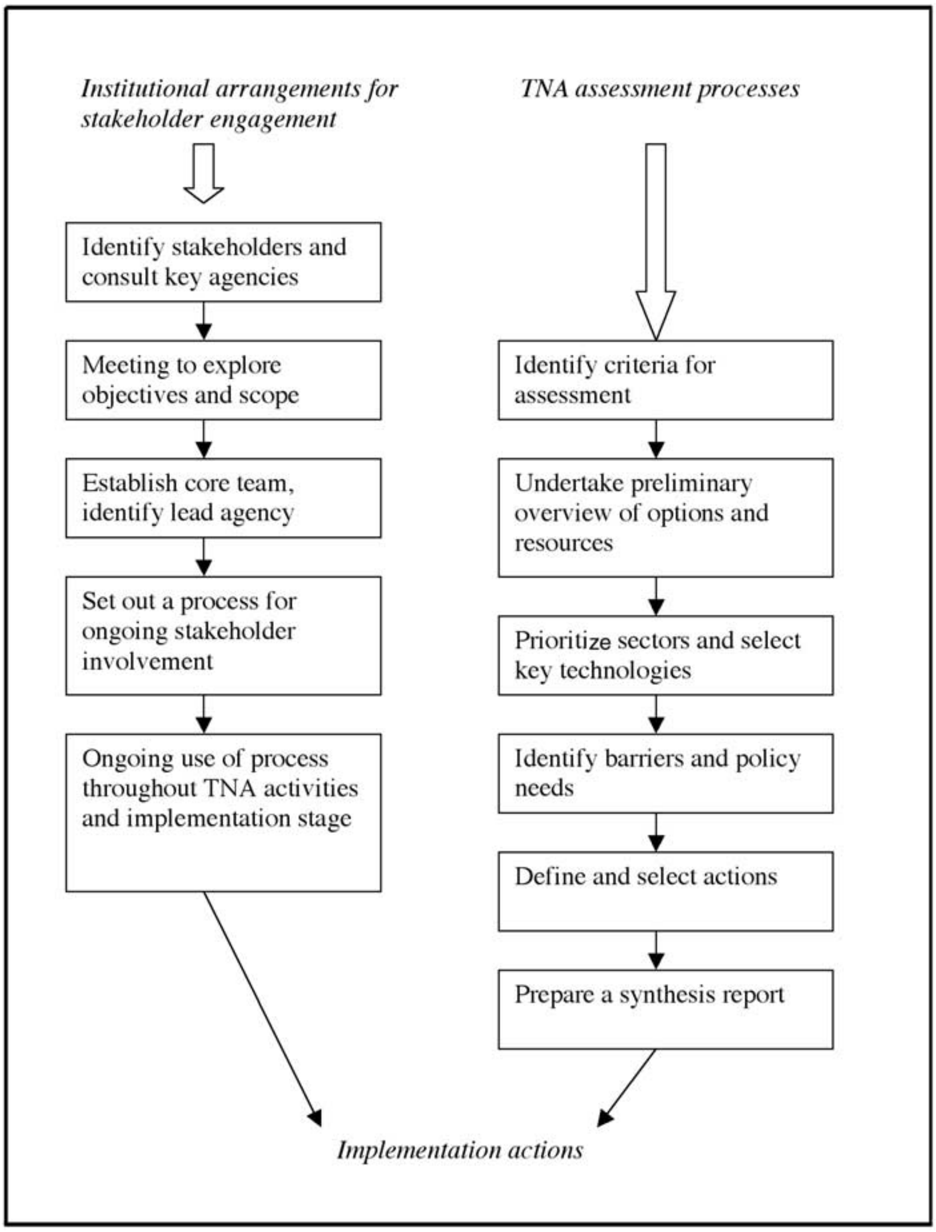

Figure 3. Overview of the UNDP/GEF technology transfer methodology.

- Local and international businesses, including project developers, technology suppliers, and sales and service groups;
- Trade organizations;
- Technical institutions;
- Technology end-users;
- International financial and donor institutions;
- Non-governmental organizations and community groups; and
- International technical experts.

(CTI 2002)

These stakeholders were motivated to organize technology transfer projects for a variety of reasons, as illustrated in the following discussion.

China. The government of China was motivated to participate in the project because of the value of cooperating with the U.S. to overcome barriers to technologies that would support China's sustainable development priorities and simultaneously reduce GHG emissions rates. This included a strong interest in building in-country capacity to manufacture, adapt, and diffuse the technologies and to access financing. In determining how the TCAPP project would work with the government of China, the choice of lead agency, between energy technologists or climate experts had implications for the scope and direction of the project. Because the climate experts engage in the UNFCCC negotiations, the decision was made that the Chinese government lead would be the State Development and Planning Commission's Office of the National Coordinator for Climate Change (SDPC-NCCC). After less formal beginnings, the project continued under a formal agreement between senior government officials: a Statement of Intent for the project was signed by Minister Zeng Peiyan of the SDPC and US Environmental Protection Agency Administrator Carol Browner in April, 1999. In addition to the SDPC-NCCC team, an interagency team was created to help direct the work. A university-affiliated institute implemented the work, and engaged energy and climate experts to work on specific technology teams.

Mexico. The Mexican government chose to participate in the TCAPP/CTP project because of its expectations that the project would provide opportunities for greater private-sector investment and market growth in clean energy technologies to reduce greenhouse gas emissions. The Mexican National Commission for Energy Savings (CONAE), a division of the Secretary of Energy, was selected as the lead agency based on the bilateral agreement that provided a formal context for the project: the U.S.-Mexico Binational Agreement, signed at the cabinet level between the Secretaries of Energy. The energy efficiency and renewable energy annexes of that agreement provide the framework for the TCAPP and CTP work. The Mexican team includes National Ecology Institute (INE), the Trust Fund for Electric Energy Savings (FIDE), the National Solar Energy Association (ANES) and others. The team's communications with Mexican climate officials were enhanced by the close working relationship and shared goals between CONAE and INE, which is part of the Secretary of Environment. INE and CONAE both presented updates of the TCAPP/CTP work at the UNFCCC Conferences of the Parties and other international climate meetings.

Southern Africa-Mauritius. CTIP activities in Southern Africa (hereafter, CTIP SA) were launched in response to a request to CTI for technical assistance from energy and environment ministers in the region. Regional ministers sought assistance in identifying clean, indigenous energy sources with the greatest potential for meeting sustainable development objectives and attracting private investment while reducing GHG emissions.

The selection of a lead government agency varied country by country in the Southern Africa region. In Mauritius, the Department of Meteorology (DoM), the lead climate change agency, became the project lead agency because of its active participation in regional meetings and its interest in greenhouse gas mitigation technology. Once bagasse cogeneration was identified as a key technology, the Mauritius Board of Investments and the Mauritius Sugar Authority, which works with all independent sugar producers, became important partners. MSA has assisted CTIP SA in gathering information, developing a strategy for an assessment, and identifying partners. Government energy sector institutions, such as the Ministry of Public Utilities and the Central Electricity Board, have also been consulted for the project.

The MSA and the Department of Meteorology have indicated that they support the CTIP SA work on bagasse cogeneration because it contributes to these national goals:

- Enhanced energy security through reduced demand for imported diesel and increased utilization of domestically grown bagasse;
- The valorization of cane sugar, a commodity that is subject to significant price fluctuations, by creating markets for non-sugar cane products;
- Increased foreign investment; and
- Mitigation of greenhouse gases.

4.1.2. *Priority technology selection*

Establishing technology priorities was the first major task addressed by the CCTT countries after organizing the stakeholders' group. The stakeholders developed criteria for evaluating potential clean energy technologies, and then ranked them. The ranking process drew extensively on available information, and sometimes priority rankings, from previous efforts such as GHG mitigation studies and action plans.

Table I lists the criteria used for evaluation and the resulting priority technologies for China, Mexico, and Southern Africa.

These three examples represent different ways of characterizing economic, development, and environmental benefits. In all three cases, both end-use efficiency

TABLE I

Priority technology selection.

Country/region	Selection criteria	Priority technologies selected
China[6]	• Environmental benefit, GHG and other emissions • Economic benefits • Conditions for technology transfer: local capacity, opportunities for local manufacturing • Scale and timeframe of potential investment in the technology	• High efficiency electric motors • Grid-connected wind electric power • Efficiency improvements in coal-fired industrial boilers • Cleaner coal electric generation options • Coal bed methane recovery
Mexico	• Economic feasibility • Technical feasibility • Attractiveness for near-term investment • Expected economic benefit for Mexico	• Efficient lighting • Energy service company business practices and market development • Solar water heaters • Efficiency measures for steam generation and distribution
Southern Africa	• Impact on social and economic development • Investment potential • GHG emissions reduction • Feasibility	• Energy efficient and solar home systems • Biomass power • Efficient motors and boilers • Green housing design • Solar crop drying • Regional gas resource development

and renewable energy technologies are included among the top priority areas. China and Southern Africa also included energy supply efficiency measures.

4.1.3. *Addressing barriers in technology markets*

After selecting priority technologies, stakeholder groups identified the barriers to the diffusion of those technologies and designed actions to address those barriers. Table II shows the barriers and actions for one example technology from each of the three countries, and summarizes the results observed in the marketplace.

TABLE II
Market barriers and corresponding actions.

Country/ region and technology	Market barriers	Technology transfer actions	Key results
China: Grid-connected wind electricity generation	• Technology risk of locally manufactured wind turbines • Lack of awareness of opportunities • Lack of wind resource data	• Training in turbine testing and certification. Official certification process. • Business partnership and brokering activities. • Support for resource assessment	• Chinese personnel trained; certification program established. • Two major investors established wind programs in China. Chinese participation in Windpower 2002. • Chinese government initiated resource assessment, identified sites for detailed measurement
Mexico: Energy Service Company (ESCO) business practices	• Mexican ESCOs' lack of project experience • Difficulties in obtaining financing and in business partnering • Lack of information among potential end-users	• Provided/translated guidelines for ESCO business practices. Training seminars. • Technical assistance to specific projects on finance and partnering issues. • Informational meetings for groups of end-users (hotel sector). Project-level technical assistance.	• 20+ ESCOs attended training seminars. • U.S. and Mexican ESCOs discussing partnership. Finance workshop organized. New finance mechanism at North American Development Bank. • Three new ESCO projects initiated in 2002.
Southern Africa (Mauritius): Bagasse cogeneration	• Lack of technology information • Difficulty in obtaining finance • Unclear regulations on independent power generation	• System-wide assessment of bagasse cogeneration; plan for demonstration project; technology field research. • Donor commitment to provide finance. • Not addressed.	• Increased understanding of and interest in bagasse cogeneration. • Development of request for proposals on bagasse cogeneration.

4.2. Summary of TCAPP, CTP and CTIP actions

The case studies above provide a few specific examples of approaches to overcome barriers to technologies in several markets. The complete scope of the activities of these programs can be organized into three categories: Project development assistance, market conditioning, and capacity building, each of which has several components as described below. Section 4.2.4 includes a complete list of the actions undertaken in CCTT programs.

4.2.1. *Project development assistance*

The technology transfer efforts described in this paper have had a strong focus on assistance to specific projects, while also supporting market conditioning and capacity building activities. The intent was to select projects for their potential to transform markets.

Understanding the technology. Prospective users need to understand the technology and its applications well enough to have confidence in it, and to ensure technology performance that can be replicated and sustained. Technology transfer programs have addressed this need by

- Providing technology information in the form of written materials, presentations, discussions, and site visits;
- Assisting in the development of technology standards and certification procedures;
- Facilitating the development of demonstration projects; and
- Organizing training workshops and study tours for prospective project developers.

Understanding the project opportunity. Once a private business is confident of the performance of a technology, then it may be interested in evaluating specific project opportunities that rely on this technology. CCTT projects facilitated this key activity by

- Conducting pre-feasibility and feasibility studies
- Disseminating information about opportunities to use the technologies through workshops, presentations, and written information;
- Assisting renewable energy resource assessments to identify likely locations for renewable energy projects and reduce resource risk;
- Facilitating audits and audit training to identify energy efficiency opportunities;
- Supporting project assessment, including the use of computer-based screening tools; and
- Providing technical support in project design and planning.

Achieving project development. A private business that is considering a project opportunity must determine its ability to assemble a capable team, either within its own ranks or through partnerships with other firms. Partnerships between in-country and international firms may be especially advantageous in a technology-intensive project because in-country businesses have local market expertise, favorable legal status, lower personnel costs, while international business partners may bring technology project development experience and additional financing options. CCTT programs have assisted this process through site visits, dissemination of project briefs, trade association collaborations, study tours, investment conferences, and other means.

CCTT also tackled one of the major barriers in project development: evaluating financing sources and securing financing. Through a variety of workshops and discussions, CCTT provided private firms with information about financing options and contacts in financial institutions. For example, in Brazil, sugar mill owners received presentations on financing options for cogeneration projects. The programs also addressed the financial institutions' perceptions of project risk by providing technology, project, and country policy information. In the case of the Philippines, workshops on wind power brought together financial institutions, project developers, and government officials.

CCTT programs also addressed the need to garner the support, or at least acquiescence, of the array of decision-makers, government officials, and other stakeholders that are important for the implementation of a project. Such activities included government involvement and government agreements to reduce the risk of adverse official decisions and development of information and outreach programs for consumers. An example is in the case of wind-diesel project development in the Philippines, where CCTT efforts assisted the project developer in engaging the government to work on policy issues for project development.

4.2.2. *Market conditioning*

In addition to encouraging the development of specific projects, developing countries implemented actions with international partners through CCTT to condition markets through assessment of market opportunities, education and outreach, policy reform and government program development, and business and financing networks.

Market assessment. Market assessment provides key information about markets that businesses, governments, and other stakeholders need to plan for the implementation of new technologies. Such an understanding can be gained through characterizing the customers, market players, market trends, technology options and other characteristics that define the status and changes needed in the market.

Policy reform and government program development. CCTT programs provide technical assistance for policy design and reform related to clean energy technologies. Policies that have been examined and used in participating countries include

- Incentives that require or support renewable resource use;
- Laws and policies on renewable resource ownership;
- Permitting for resource use and project development;
- Taxes and subsidies (on equipment, on competitor technologies);
- Standards for equipment;
- Loan guarantee programs;
- Direct grant support, international development assistance priorities; and
- Contract laws influencing opportunity for Energy Service Contracts.

For example, the TCAPP program in the Philippines sponsored policy analysis and development to streamline policies governing

- Requirements for corporate track records for developers of renewable electricity generation;
- Spinning reserve and thermal efficiency requirements;
- Power purchase agreements;
- Review of projects by Philippines Department of Energy planners.

Documenting and disseminating results. In the early phases of market development, information about results of initial projects is a valuable catalyst for interested businesses. CCTT emphasizes documenting and disseminating results of the projects where it provides assistance.

Business and financing networks. Business and investor networking represents a fourth type of CCTT activity for overall market development. This activity can take many forms, including development of trade associations, trade missions and reverse trade missions, support for business conferences, and business matchmaking services.

4.2.3. *Capacity building*

Capacity building is an essential component of technology transfer, specified in the UNFCCC Article 4.5 reference to the 'know-how' that must accompany technologies. As such a high priority, it permeates many of the other activities mentioned in this summary of CCTT actions. Training seminars, workshops, development of educational materials, and a variety of other activities build capacity to use the target technologies in developing countries. These capacity building activities have included

- Training workshops and study tours on specific technologies and applications;
- Assistance with business planning
- Training on standards, testing methodologies, and certification procedures;
- Training on project development and business planning;
- Education and outreach programs about specific technologies;
- Training on financing.

TABLE III

Summary of country technology priorities and selected actions for climate technology transfer programs (TCAPP, CTP, CTIP and CTI support for technology needs assessments).

Country	Program	Lead agency	Primary technology priorities	Selected major actions
Brazil	TCAPP and CTP	Ministry of Mines and Energy	Sugar Mill Co-generation Rural Renewable Energy Transportation Efficiency	Market assessment Project development and financing assistance Diesel offset assessment Project development Investment conference
China	TCAPP and CTP	State Development Planning Commission	Grid-Connected Wind Power Efficient Motors Efficient Industrial Boilers Clean Coal Technologies	Wind resource assessment, Turbine testing and certification training. Motors financing seminar and pilot testing Advanced boiler technology conference and pilot testing Pressured fluidized bed combustion technology workshop
Ghana	UNDP-Funded Needs Assessment with CTI technical support	Ghana Environmental Protection Agency	Lighting efficiency Industrial Energy Efficiency Landfill methane Biomass resource Assessment	Development and implementation of multi-mode plan for transforming market for CFL lamps
Egypt	TCAPP and CTP	Environmental Affairs Agency	Petroleum Refinery Efficiency Rural Renewable in Agriculture	Refinery retrofit demonstration, implemented by Egyptian ESCO Workshop on hybrid renewable systems.
Kazakhstan	TCAPP	Ministry of Energy, Industry, and Trade	Power Plant Efficiency District Heating Improvements Wind Power Small Hydropower	Actions were developed, but work was ended prior to implementation of actions

TABLE III
Continued.

Country	Program	Lead agency	Primary technology priorities	Selected major actions
Mexico	TCAPP and CTP	National Commission for Energy Conservation (CONAE)	ESCO Market Development Solar Hot Water Heating Wind Power Development	ESCO project identification and development Business matchmaking and financing assistance Model performance contracts Solar water heater market assessment Business matchmaking Financing assistance Wind resource assessment, Policy and wind project development support
Philippines	TCAPP and CTP	Department of Energy	Rural Renewable Energy	Policy reforms Training for rural electric cooperatives and others Technical support for diesel retrofit opportunities
Republic of Korea	TCAPP and CTP	Korean Energy Management Corporation	Energy Audit Training & Management Landfill Methane Recovery	ESCO Market Development – Auditing Training – Project Development – Business Matchmaking – Financing Assistance Training on Methane Recovery Project Development and Business Matchmaking
Southern Africa	CTIP	Southern Centre for Energy & Environment and Lead Agencies in each country in the region	Bagasse Cogeneration Solar Water Heaters	Feasibility Study to identify investment opportunities Project development support Consumer awareness campaign Low-cost financing of SWH units for consumers

4.2.4. *TCAPP, CTP and CTIP actions*
Table III presents a complete list of the main activities of all these programs to date.

4.3. Measuring results

4.3.1. *Reported program results*
Measuring program results is a challenge for a variety of reasons. The content of results reports has evolved over the course of CCTT progress. Table IV shows the format used as of 2002, applied to the subset of countries that participated in the CTP program. This example includes the following direct and indirect program impacts:

- Development impacts;
- Training and capacity building;
- Policies and programs;
- Business partnerships;
- GHG emissions;
- Energy savings;
- Investment $ leveraging;

4.3.2. *Challenges in measuring results*
The results reported in Table IV could be improved upon if more resources were devoted to this effort than were available for that preliminary assessment. Results measurement for CCTT faces difficulties of quantifying program achievements and in attributing those achievements to the program, rather than outside forces.

In addressing these difficulties, CCTT programs may draw upon the perspectives of economics, public administration, business management and accounting, industrial engineering, marketing research, and international development on evaluation of performance, productivity, and effectiveness.

Cost-benefit analysis forms the standard basis for program evaluation based on economics (Mishan 1994). Duke and Kammen (1999) apply these techniques to market transformation programs such as those under consideration here, illustrating some of the particular challenges. Birner and Martinot (2002) evaluate a developing country market transformation program. From the public administration literature, Lynch and Day (1996) provide further insights into the limitations of cost-benefit analysis for the evaluation of public programs.

Other disciplines provide methodologies that might be useful in measuring non-financial results and overall program effectiveness. These include Balanced Scorecards (Kaplan and Norton 1996a, 1996b) and Total Quality Management Gopal (1990). Relevant industrial engineering literature on productivity includes Singh et al. (2000), Stainer (1999), Stainer (1997), and Flapper et al. (1996). McAdam and Saulters (2000), Kouzmin et al. (1999), Hodgkinson (1999) provide a number of cautions about the pitfalls in transferring these performance measurement

TABLE IV

Format of results reported for TCAPP/CTP program.

Country	**Development impacts**	**Training and capacity building**	**Policies and programs**	**Business partnerships**	**GHG emissions**	**Energy savings**	**Investment $ leveraging**
Brazil	Improved economics of sugar mill production; Increased energy supply to handle energy crisis; Enhanced in-country finance capacity	Over 15 sugar mill owners in the NE contacted to discuss opportunities for sugar mill cogeneration projects; Two sugar mill owners signed MOUs to receive financing and technical assistance for cogeneration projects.	Energy scenarios strategy currently under development for one of the partner sugar mills, which could be replicated for other sugar mills in the region; Discussions with the local utility regarding power purchase agreements could also lead to the development of PPAs for other sugar mills in the region.	Vibhavac coordinating with the other Winrock cooperators involved in cogeneration activities, and the private sector.	At total market replication, sugar mill cogeneration projects in the NE will potentially reduce CO2 on the order of 1.6 million tons per year over lifetime of projects		The 2 identified projects in the NE represent investments of about $12 million; Full market replication greatly exceeds $50 million worth of investment
Egypt	Direct benefits to economy and air pollution reductions through energy savings for oil refinery retrofits and use of renewable energy for agricultural applications.	Forty participants, many agencies, at renewable energy workshop. One senior climate official and two key climate change staff members participated in work in FY02.	Expected to lead to program of refinery efficiency retrofits and enabling policies and programs for ESCO industry success.	Promoting partnerships to conduct energy efficiency retrofit of Suez Oil Processing Company through the emerging ESCO industry. Also promoting relationships between agribusinesses and renewable energy suppliers	Current projects: 110,000 tons CO2 total. Industry-wide: 200,000 tons per year.	Current projects: 25,000 BOE/yr. Industry-wide: 7 million BOE/yr.	Refinery project: $2 million private funds. Industry-wide: $100 million.

TABLE IV

Continued: Format of results reported for TCAPP/CTP program.

Country	**Development impacts**	**Training and capacity building**	**Policies and programs**	**Business partnerships**	**GHG emissions**	**Energy savings**	**Investment $ leveraging**
Mexico	Improved economic performance of industrial plants and hotels; Reduced local air pollution and greenhouse gases; Enhanced in-country finance capacity; Improved economic development and increase in employment; Opportunity to increase foreign direct investment	After 5 events and 29 site visits, the team has established a direct contact with over 80 energy end-users; 30 have noted their interest in knowing the benefits of the ESCO scheme and in assessing potential projects after receiving training in performance contracting and energy savings measures	Establishment of ESCO Pilot Program for Government of Mexico; Model Performance Contract Developed	Ameresco and Optima are currently discussing projects in Monterrey and plan to sign an MOU for work on projects together by November, 2002; Several other Mexican and international ESCOs have expressed interest in forming a partnership to carry out these projects.	Potential for the 2 identified projects may reduce CO2 emissions by up to 500,000 tons over their lifetimes; Full market replication of the ESCO market in just the industrial sector could amount to 37 million tons CO2 avoided.		2 projects have been signed and 1 project is currently under negotiation, which represent about $5 million USD in investment; Full market replication of the ESCO market in just the industrial sector could amount to $10 billion of investment.

TABLE IV

Continued: Format of results reported for TCAPP/CTP program.

Country	**Development impacts**	**Training and capacity building**	**Policies and programs**	**Business partnerships**	**GHG emissions**	**Energy savings**	**Investment $ leveraging**
Philippines	Facilitating use of renewable energy and hybrid systems in remote areas will reduce poverty, promote national economic development, and reduce air pollution	Over 100 technical representatives and government officials have received training	Technical guidance to PDOE has resulted in development of several internal technical guidance documents and overall effort has supported the development of the Renewable Energy Bill	Have facilitated the engagement of over 7 international renewable energy businesses in the Philippines in partnership with Philippine organizations	Over 500,000 tons of CO2 per year will be reduced if the 17 most promising projects for use of renewable energy in remote areas that have been identified through the CTP work are fully implemented	Over $6 billion in fuel imports will be saved if the most promising renewable remote island grid projects are implemented.	$500 million in private investment will be achieved through full-scale implementation of diesel retrofit opportunities. Over $20 million of large wind farm projects under investigation
Southern Africa	Supporting economic development goals leading to improvements in indoor air quality.	20 community members in Klaarwater and Lusaka townships trained.	Durban Metro Housing Authority is considering a follow-on program building on this project.	Partnerships created with three SWH businesses.	Reduction of an equivalent of 42.5 kilotons of carbon dioxide annually from completed and scheduled installations (by December 2002) and the projected reduction of an additional 32–42.5 kilotons of carbon dioxide equivalent annually as a result of anticipated orders.		*Consumer investment of US$5000 for the scheduled installation of 100 units. Additional investment projected $7,500–1,000 from 2003 orders.*

approaches from the private sector to the public sector. Work assessing the result of international development efforts often combines several of these viewpoints, as illustrated by Najam (2002), Easterly (2002), Lozada (2002), and World Bank (1998).

Conventional wisdom holds that what's measured gets done. Taking this to heart, and considering the measurement of CCTT results to date, we believe that evaluation and improvement of the results measurement process will remain an important part of CCTT programs. Improvement to results reporting would occur on at least two dimensions: modification of the results that are measured, and improvements to the measurement methods, especially if CCTT efforts grow. Measuring capacity building – the 'know-how' side of technology transfer – also may require more attention. Existing methods are useful here, such as USAID reporting metrics that track training of in-country personnel.

Using these case studies, the summary of different types of CCTT actions, the lessons from CCTT experience, and bearing in mind the issues of measuring results, we now draw some conclusions about the implications of CCTT projects to date.

5. Interpretations and Implications

5.1. Lessons learned

Lessons on country stakeholder participation and organizational context. Lessons regarding stakeholder participation and organizational context relate to the lead in-country government agency and the roles of other country stakeholders, the implications of this organizational context for project scope and effectiveness, and to the feasibility of regional processes.

The choice of country lead agency, the engagement of other stakeholders, and the relationships among these players are crucial for project implementation. The climate change agency may be the lead agency for CCTT because of its direct connections to the UNFCCC. Alternatively, the energy agency may be the lead because of its technical expertise with the relevant energy technologies. In either case, partnership between the two types of agencies appears to help CCTT achieve both technology implementation and relevance to the UNFCCC. For example, in Mexico an energy agency, CONAE, served as project lead, and its close working relationship with an environmental agency, INE, allowed the project team to tap resources from both sectors. In China, the lead climate change agency, SDPC-NCCC served as project lead, and had a more distant relationship with its energy counterpart, making coordination more difficult.

Other government agencies may be involved depending on the administrative structure of the country. Government agencies that have good working relationships with interested, influential stakeholder groups may be especially helpful to engage these stakeholders. For example, the involvement of the Mauritius Sugar Authority helped establish connections with the sugar estates for the bagasse co-generation project.

The involvement of all the relevant stakeholders listed in Section 4.2.1 is essential to project effectiveness. Engaging these stakeholders is important to coordinate technology transfer efforts with government initiatives for sustainable development and to build support among constituents important to technology transfer implementation.

The involvement of stakeholders, and especially the choice of the lead agency, can be important in determining what issues are within the project scope. For example, in both China and Mauritius, policy issues were not within the authority of the lead agency to address, and so were not included in the universe of actions considered. In other countries, policy actions were considered along with private sector and multilateral donor actions. For example, the Philippines implemented policy reforms that directly addressed regulatory barriers to the implementation of renewable energy technologies.

The example of Southern Africa provides a cautionary tale about the complexity of working at a regional level, and suggests that such approaches may be inadvisable unless strong regional institutions exist. The regional process in Southern Africa posed special challenges for stakeholders. The CTIP SA project attempted regional work where few strong regional institutions exist. Limited regional institutional experience, coupled with limited resources to engage stakeholders in each country, means that identifying, engaging, and regularly consulting stakeholders is an on-going challenge.

Lessons on priority technology selection. The process of developing selection criteria and selecting priority technologies emphasized consultative processes to engage relevant stakeholders that were helpful in drawing ideas from diverse perspectives and in building support from important allies. Limited resources for needs assessments meant that technology priority selection relied heavily on previous studies and information, and in some cases on previously established priorities. These limitations may be acceptable, but it must be recognized that they prevent stakeholder groups from fully re-examining technology priorities *de novo.*

Identifying and engaging appropriate stakeholders for priority technology selection is a challenge because it requires anticipating what technology markets may be most important and most amenable to influence. This leads to a 'chicken-and-egg' relationship between engaging relevant to key technology areas and the set of technologies that are selected by the stakeholders group. Private sector stakeholders, whose judgments can be particularly insightful, are often the most difficult to engage.

The Southern Africa regional work raised unique and difficult issues in priority technology selection. In that effort, the extent of stakeholder consultation for priority technology selection varied depending on each country's resources.

More importantly, applying the same selection criteria obtained different results for each country because of the diversity of economic, market, resource, and social conditions, yet regional technology priorities were ultimately selected. As a result, priority selection in a regional context does not necessarily achieve optimal results in each country.

Background information can assist the selection of priority technologies, yet such information may be costly to develop and difficult to use. Many countries already have background information that can assist the selection process. Where important elements of background information are not available, technology transfer teams make difficult choices between devoting project resources to further research, or selecting priority technologies based on the best available information. An iterative, flexible approach may help deal with the reality of imperfect information.

In the process of technology selection, the technologies of interest to some stakeholders necessarily become lower priorities. In CCTT projects to date, these potentially conflicting interests have largely been resolved by default, in that stakeholders interested in technologies beyond the scope of the priorities have simply lost interest in the project, which may not be the most desirable outcome.

Lessons addressing barriers in technology markets. The lessons in identifying and addressing technology barriers relate to the level of analysis, the design of actions to address barriers, input and support from the private sector and other stakeholder, private sector networks and information exchange, and the importance of financing.

CCTT programs have used different levels of analysis and stakeholder consultations to assess barriers and potential actions to address barriers. These ranged from informal analysis based on readily available expert opinion to more systematic studies based on market data and a wider array of expert opinion. The level of analysis must be carefully matched to needs and resources, and it appears that more detailed studies were well worth the effort where they were conducted. For example, the bagasse cogeneration work in Mauritius started with a more detailed pre-feasibility market assessment. At a cost of about $10,000, this assessment provided detailed information including a description of the consolidation process underway in the industry, during which some sugar estates will likely close and others expand. Such industry data is crucial to have when determining sites for cogeneration plants.

Planning the design of actions requires careful thought to anticipate how the various elements will work together. Successful technology transfer, a change in technology regime, may require substantial changes on many fronts. Careful planning may suggest an optimal order in which actions should be undertaken, highlight items that are on the critical path, and help determine the timing of events for the technology transfer project to proceed in a timely manner.[7]

Input from the private sector and other stakeholders is crucial to understand and remove barriers to technologies. Business networks are invaluable tools for technology transfer, because they help identify potential projects, provide information to potential project partners, identify barriers and ways to overcome them, review results, and otherwise 'grease the wheels' of the technology transfer process. Some CCTT projects, such as those in Southern Africa, have suffered from the difficulties in obtaining private sector input. The existence, interest, and capabilities of relevant businesses and trade associations, and the experience of government agencies in working with them, are important determinants of private sector input.

For example, in Southern Africa as a whole, there are very few energy efficiency or renewable energy businesses, and limited opportunities for trade associations to form and prosper. Thus CTIP South Africa had difficulty in engaging business to understand and remove barriers to technology markets. The choice of bagasse cogeneration as a priority technology circumvents this issue by focusing on sugar estates and bringing in international cogeneration technology expertise, and ideally would develop similar expertise locally. In contrast, in the case of ESCOs in Mexico, Mexican businesses were already looking to develop energy service performance contracting, and networks of energy users were available to disseminate information to potential clients. The project established national and international networks that raised awareness of ESCO projects through outreach workshops and site visits.

The value of strong support from a variety of stakeholders also should be noted. Actions to remove technology barriers can be most successful when they leverage resources from a number of different stakeholder groups. Such constituencies might include in-country businesses seeking to develop a new market, financial institutions seeking to grow a portfolio, government agencies seeking to meet economic development goals, and international businesses seeking opportunities in a country. For example, in the Philippines, a Filipino subsidiary of an American wind energy development company sought to develop hybrid wind-diesel energy systems, and worked closely with the Department of Energy that sought to use indigenous energy resources to improve electricity systems on remote islands, while a number of financial institutions expressed interest in increasing their renewable energy portfolios. CCTT projects may be able to weave together such interests to catalyze project development and market growth.

Financing is another essential component. Experience with CCTT highlights the importance of matching projects, companies, and financing sources. The Mexico project illustrated the hurdle created by financing transaction costs and difficulty of creating a match between projects and companies. It proved challenging to identify projects that were large enough to interest international ESCOs and large financial institutions. Yet, at the beginning of the project, the Mexican ESCOs that might have been a better match for smaller projects lacked the capability to undertake them. The experience of the project resulted in a better understanding of the match between project size and project team, and also in the identification of bundled projects in the public sector as a new area for future work.

Other lessons. Several overall lessons should be noted, including the need to connect CCTT to development goals and programs at all stages, the importance of developing champions, the value of flexibly refining and adapting CCTT projects as work progresses, and the importance of matching the numbers of technologies and actions with the available resources. With program funding levels to date, CCTT programs were most effective when they implemented only the top one or two technologies in order to maximize impact.

5.2. Implications for Future Efforts

As described above, many of today's climate change technology efforts grew directly or indirectly from the experience and relationships established through the implementation of enabling activities such as support for country studies and national communications by the GEF and bilateral programs. The experience in the TCAPP, CTP and CTIP programs provides the following suggestions that we hope will in turn be useful in building on and expanding those efforts.

1. First and foremost, climate change technology transfer must remain a country driven process to ensure that it meets high priority development needs while also addressing climate change response goals. Implementation of technology transfer programs should be tailored to each country's priorities and circumstances. One size does not fit all.
2. Existing climate change technology transfer methodologies provide a good starting point that countries can adapt to fit their particular requirements. Further international efforts should focus primarily on helping countries adapt and apply existing methodologies rather than on further methodology development. The methods can nevertheless continue to improve over time through sharing accumulated experience.
3. Active and broad stakeholder participation is vital to success. Stakeholders should participate actively in every stage of the process from priority setting through action design and implementation.
4. Technology needs assessments should include a detailed analysis of markets, barriers, and potential actions, and should identify a portfolio of high priority actions that will address critical market barriers.
5. The technology needs assessment process needs to be clearly coupled to a viable, well-defined implementation process. Technology needs assessments will only be effective where they are tied to effective mechanisms for applying the results to facilitate implementation.
6. Developing countries have faced several barriers with implementation of technology transfer programs, including a shortage of appropriate local capacity and expertise, limited resources, difficulties in engaging the private sector, and

limited access to technology information. These limitations need to be kept in mind in designing technology transfer efforts.

7. Effective technology transfer implementation requires linking actions by host country governments, the private sector, and international donors, applying the combined resources and expertise of that community to achieve sustained technology diffusion. These efforts will have the greatest success where they build on and are integrated with existing development programs.
8. Countries can pursue a broad range of technology transfer actions that generally fall into three categories: capacity building, investment facilitation, and market conditioning.
9. Climate change technology transfer programs will be most effective where they match the number of sectors and technologies that they address with the financial and personnel resources available. Since resources are limited, such programs need to quickly identify a manageable number of sectors and technologies for in-depth analysis and action design and implementation.
10. Climate change technology transfer implementation should occur through an iterative process where priorities and actions are adjusted through initial experiences gained from implementation of actions. Accordingly, technology needs assessment reports should be viewed as adaptable, ‘living’ documents.
11. The definition of acceptable metrics for evaluating market transformation, perhaps suggested by additional research along the lines of Duke and Kammen (1999), would be helpful in guiding the evolution of the overall effort.

5.3. Conclusions

The leading challenge in technology transfer practice is to scale up the pilot efforts conducted to date so that they can achieve the desired market transformations that are an essential element of technology transfer. This effort will require resources orders of magnitude larger than those available in the pilot efforts.[8] Both the amount of resources and the precise mechanism for their allocation are still under discussion within the UNFCCC.

Creating a successful, broad scale multilateral coalition for technology transfer represents another important next step. Many CCTT efforts to date have been bilateral. CTI sponsors important multilateral work that needs to be extended further to create real partnerships and synergies between donors in different countries. In Southern Africa, for example, during the implementation phase, individual projects developed essentially as bilateral relationships between one donor and one host country.

Climate change technology transfer faces two additional challenges in integrating with other ongoing donor programs in each developing country. First, the donors in each host country have to become aware of, and engaged in, the technology transfer efforts. Enough resources have to be available for technology transfer programs to carry some weight – indeed, to be noticed – in the larger scheme of ongoing development work. Secondly, this integration will have to walk a very fine line because developing countries will continue to insist that the resources for climate change technology transfer be 'additional' to official development aid that would have been forthcoming without technology transfer. The developed countries will not be seen as fulfilling their obligations under Article 4.5 if the resources for those activities appear to be coming from the budgets of other aid projects. Some countries, such as Ghana, are beginning to reach the point in their technology transfer process where these issues begin to surface. There have been some initial steps toward crafting solutions and criteria for this resource allocation, but more needs to be done.

Finally, the fact that the precise mechanism for UNFCCC technology transfer implementation has yet to be defined by the UNFCCC creates difficulties in pursuing climate change technology transfer. These problems are most acutely felt in those countries that are ready to implement technology transfer actions. Without an operational implementation mechanism, it is difficult for the developing countries that are paving the way for others to secure the international support necessary to implement the priority actions emerging from these assessments.

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Notes

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2. 'UNFCCC' is commonly used to describe both to the Framework Convention document and the partnership of countries participating in the cooperative efforts initiated by the signing of the document. We will also use 'UNFCCC' in both these senses, but 'Framework Convention' will refer only to the document.
3. Although both mitigation and adaptation technologies are specifically included in the technology transfer goals of the UNFCCC as described below, very little work has been done in transferring adaptation technologies.
4. As of this writing, the CTI member countries are Australia, Austria, Canada, Denmark, the European Commission, Finland, France, Germany, Ireland, Japan, New Zealand, Norway, Sweden, United Kingdom, and the United States.
5. These two objectives may be seen as conflicting. In practice, there has been a tacit understanding that has combined them by focusing first on economic and development benefits to the developing country partner with the stipulation that some amount of emission reductions or avoidance also occur. Commentaries on strategy for technology transfer often emphasize the value of avoiding future GHG emissions by the large number of developing country citizens currently without access to modern energy sources, but this concept has never been precisely formalized.
6. China and the U.S. agreed to cooperate on the first four of these through the 1999 agreement, while cooperative work on coal bed methane recovery was pursued through a separate bilateral agreement. It was further agreed that the project would start with two technologies and add two more each year.
7. Cowan and Kline (1997) point out that the order in which policies are undertaken can be critical in overcoming technology lock-in.
8. As a point of reference, many of the TCAPP/CTP and CTIP projects have budgets less than \$100,000 per year per country. The GEF-sponsored Efficient Lighting Initiative projects, which are making significant progress toward market transformations, have budgets of several million dollars per year, and focus only on a small set of lighting technologies (Birner and Martinot 2002).

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